WHITE PAPER

The Benefits of Demand-Side Management and Dynamic Pricing Programs

McKinsey & Company

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"Without the ability of end-use electricity consumers to respond to prices, there is virtually no limit on the price that suppliers can fetch in shortage conditions."—William Massey, FERC Commissioner, August 2000

"The demand side of the market is not functioning well because customers are not seeing real-time price signals . . . With real-time pricing options and their supporting technologies in play, we would get the full benefits of deregulation."—Ahmad Faruqui, Electric Power Research Institute

EXECUTIVE SUMMARY

The wide-scale deployment of dynamic pricing[1] has the potential to promote long-term efficiencies in electric power markets. Current rate structures provide consumers with little understanding of the underlying cost of the electricity they consume. As a result, they are unable to react to daily or hourly fluctuations in wholesale market prices by changing their consumption behavior. The variability of demand is one of the primary causes of wholesale price-spikes and, in the case of markets with tight supply constraints such as California, contribute to rolling blackouts. By more closely linking retail prices to wholesale prices, end users would have greater incentive to reduce their consumption on peak, which would in turn lead to lower overall energy costs for all.

Our conservative estimate is that the wide-scale (i.e., national) implementation of dynamic pricing would result in annual electricity cost savings on the order of $10 billion to $15 billion. Approximately 20 percent of total financial savings comes from individuals reducing their consumption during peaks; the remaining 80 percent is generated by the lower wholesale peak prices that result from reducing peak load and accrues to all consumers. In addition, there could be significant societal benefits associated with implementing dynamic pricing.

With falling technology and digital communications costs, the infrastructure needed for dynamic pricing can now be brought to the mass market, albeit with relatively long payback periods (5 to 6 years). However, since so much of the benefit of dynamic pricing is the result of collective and not individual usage, a free-rider problem threatens to prevent this deployment. By our estimates, dynamic pricing would have to be extended to one-half or more of mass market customers in order to deliver positive economics. Such a wide-scale deployment will require an institutional solution.

This whitepaper summarizes our belief that dynamic pricing solutions and demand-side management programs can be powerful complements to the supply-side initiatives required to create an enduring energy policy.

[1] Dynamic pricing refers to any pricing option in which prices change in response to changes in costs. This can include time-of-use (TOU) rates, which are set based on expected wholesale prices or real-time pricing (RTP) in which actual market prices are transmitted to customers.

DEREGULATION: THE INCOMPLETE EXPERIMENT

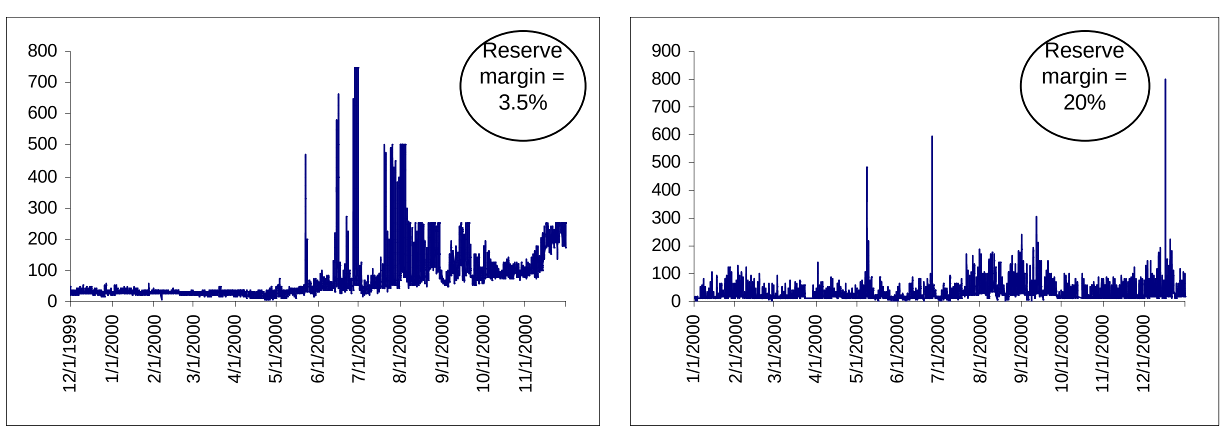
Given recent turmoil in restructured electricity markets, many observers have begun to question whether deregulation is delivering the anticipated benefits to consumers. The problems in these newly deregulated markets, however, should not be interpreted as evidence that electricity restructuring has been a failure. Rather, restructuring is not yet complete—and it will not be complete until retail and wholesale markets are more effectively linked.

Many of the recent, headline-grabbing problems in electricity markets can be attributed to a short-term imbalance of supply and demand. Over time, as new generating resources and additional infrastructure are brought on line, the high prices witnessed in the Western United States should fall. However, the lack of connection between wholesale and retail markets will continue to present longer-term problems in all markets. The reason is that wholesale prices for energy are highly volatile, and under current regulatory structures, there is no way to tie consumer demand to actual market prices for power. In other words, there is no market mechanism at present for managing the demand side of the equation.

Evidence shows that this price volatility exists in all energy markets. As shown in Exhibit 1, wholesale prices in the California Power Exchange averaged $81/MWh, with a range from $6/MWh to $750. The high average price is reflective of tight supply conditions. California's reserve margin for Summer 2000 was only 3.5 percent compared to standard utility practice of carrying a 15 percent cushion. But even in markets with excess capacity, wholesale electricity prices exhibit significant volatility. For example, in the Pennsylvania, New Jersey, Maryland power pool (or PJM), the average price was $34/MWh, but ranged from a low of $10/MWh to a high of $800/MWh, despite a reserve margin of nearly 20 percent.

EXHIBIT 1 — PRICE VOLATILITY IN WHOLESALE POWER MARKETS – 2000

California **PJM***



* Pennsylvania, New Jersey, Maryland power pool
Source: California Power Exchange; PJM ISO; McKinsey analysis

Dollars/MWh

The causes of the fundamental volatility of electric commodity prices are varied. Unlike other commodities, electricity cannot be stored in large quantities; consequently, as demand increases over the course of a day or a season, more expensive (peaking) capacity must be dispatched to serve additional load. Since natural gas is the fuel of choice for these peaking plants, their marginal costs are, in turn, affected by volatility in gas markets. Beyond "peaker" plants, the cost of generators varies significantly, which contributes to market variability. Additionally, consumer loads themselves change significantly over the course of a day, which increases the volatility of prices.

This market volatility combined with consumption inefficiencies imposes significant costs on society: the most obvious of which are the interruptions, rolling blackouts, and financial distress that currently plague the Western United States. But there are other economic and social costs as well, including the need to build capacity and related infrastructure and consume natural resources in the provision of electricity that could be avoided altogether.

ONE SOLUTION: DYNAMIC PRICING

If deregulation is ever to be complete, utilities and policy makers must find a way to better link retail demand to wholesale market forces, especially at the level of residential and small commercial end users. Many large commercial and industrial customers already have time-of-use programs in place. By exposing smaller customers to dynamic (or time-varying) prices, end-users would have the incentive to curtail demand at peak times and to shift their demand from high- to low-priced periods—resulting in significant savings.

A conservative estimate indicates that the economic benefit gained from shifting even small amounts of demand away from peak price periods could range from $10 billion to $15 billion annually. (See Exhibit 2.) This analysis assumes that all users would shift approximately 5 to 8 percent of their load consumption from peak periods (roughly 3 hours a day) to off-peak hours and would curtail usage of another 4 to 7 percent altogether during peaks.[2] These assumptions have been substantiated by actual experiments with real-time pricing, such as one in Texas where some consumers shifted and curtailed as much as 36 percent of their demand during price peaks.[3]

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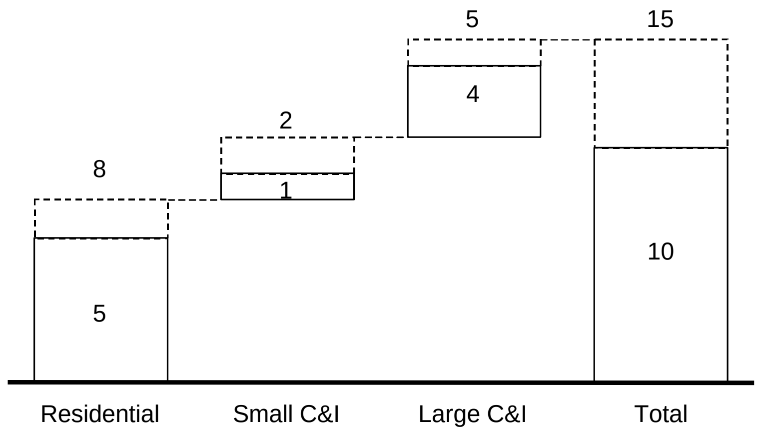
2 Based on PJM hourly loads and prices for the Year 2000, extrapolating to a national set.

3 According to a study by consultants Eric Hirst and Brendan Kirby. Over a 5-hour period, participants in the study reduced an average of 15 percent of their demand.

EXHIBIT 2 — ECONOMIC BENEFITS FROM DYNAMIC PRICING *ESTIMATE*

$ Billions



	Residential	Small C&I	Large C&I	Total
Percent of total value	53	10	37	100
Percent of total load	40	10	50	100

Note: Assumes customers shift 5 to 8% of peak load to off-peak hours and curtail an additional 4 to 7% of resulting peak load; savings based on actual prices and load for PJM power pool in Year 2000 extrapolated to national load; peak hours defined as highest 10% of daily and annual prices

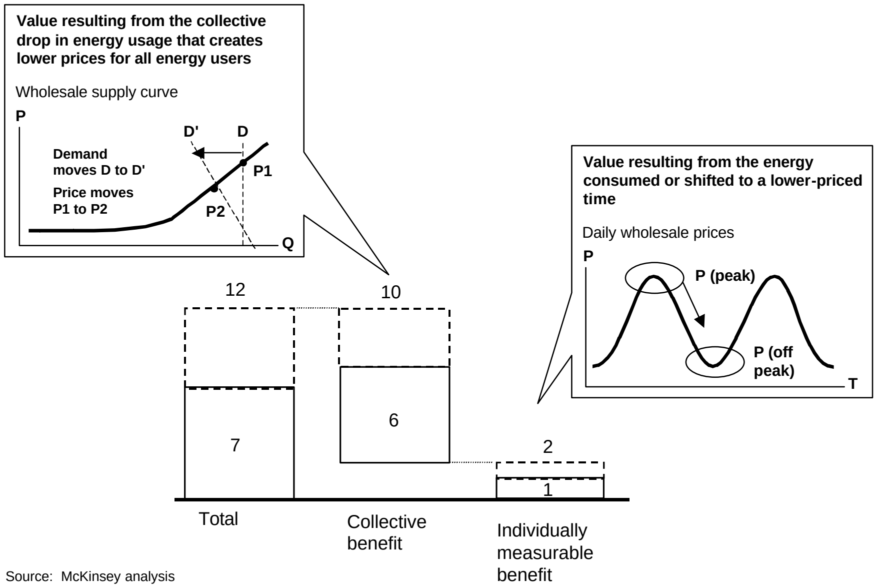
Source: PJM ISO; McKinsey analysis

Changing consumption patterns during peak periods reduces energy cost savings in two ways. As shown in Exhibit 3, about 20 percent of the value created by dynamic pricing comes from individuals responding to high prices and curtailing electricity consumption—e.g., turning off lights or increasing their thermostat by several degrees in the summer—or shifting consumption to non-peak periods—e.g., by running a dishwasher or water heater at night. However, there is a second-order effect of this reduction in peak demand that results in even greater savings—nearly 80 percent of the total value created. As more customers respond to wholesale market conditions, demand for peak energy drops, resulting in a lower market-clearing price for all energy consumed at that time.

EXHIBIT 3 — ECONOMIC BENEFITS FROM DYNAMIC PRICING IN MASS MARKET

$ Billions

ESTIMATE

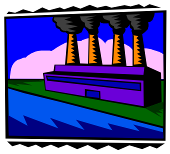


Source: McKinsey analysis

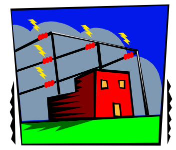
Shifting and curtailing demand would also lead to benefits beyond the obvious economic gains. With universal application, peak energy demand could be lowered by at least 30,000 MW nationally, translating to perhaps as many as 250 peaking plants that would not need to be built. Society could avoid the burning of 680 bcf of gas per year and the resulting 31,000 tons of NO_x emissions. Water quality would be improved, and stresses on land use would be relieved. Additionally, by deploying dynamic pricing programs, utilities could optimize other parts of their value chain that are driven by peak demand—gas storage as well as electric transmission and distribution capacity. They would also achieve some reduction in metering costs by installing automated meter reading systems that would be required to support real-time or time-of-use pricing. Exhibit 4 summarizes these additional benefits.

EXHIBIT 4 — INDIRECT BENEFITS OF BROADLY DEPLOYED DYNAMIC PRICING SOLUTION

ESTIMATE

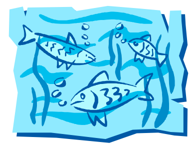


- ~250 “peaker” plants not built
- Power infrastructure for peaks reduced by 31,000 MW, saving $16 billion in capital costs (one-time)

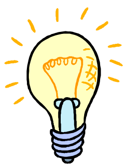


- 31,000 tons of NO_x not emitted (per annum)

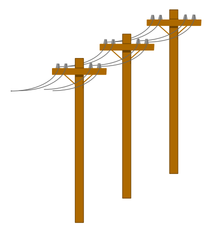
- Reduction in water used for hydro electric generation
- Gas demand reduced by 680 bcf/year
- Gas transmission reduced by 2 bcf/day



- Other environmental benefits, e.g.
  - Cleaner water
  - Thermal pollution
  - Hydro power impact on ecosystems



- Enough saved electricity to supply 7 million new homes annually
- Significant benefits for avoiding blackouts (lost productivity)



- Other system benefits
  - Avoided transmission and distribution investment
  - Reduced meter reading costs

Notes: Assumes 125 MW peaking plant, $500/kW capital cost, 25% load factor, 10,000 heatrate, 0.9 lb NOx/MWh
Source: Department of Energy; EIA Power Annual Volume II; BAEF Report; EIA RECS 1997; McKinsey analysis

Implementing dynamic pricing programs need not be complex. A basic solution—requiring only real-time or time-of-day metering and billing—could achieve significant results. Consumers would manually set their appliances and home systems to run in off-peak periods, or they would use less energy during peak times of the day. Financial incentives would be communicated through bills that reflected actual costs. Over time, as network technology and standards evolve—and costs drop—the emergence of smart appliances and home networks could support automated real-time response to energy price signals.

THE CHALLENGES OF DYNAMIC PRICING FOR SMALL USERS

So if implementing dynamic pricing for residential and small commercial users is so beneficial, why have so few companies pursued it?[4] Despite the significant value at stake, several barriers prevent the wide-scale deployment of more dynamic pricing in retail electricity markets: current rate structures, inadequate infrastructure, and the necessity of wide-scale deployment to achieve significant benefits.

First, most customers are currently charged for usage under a regulated rate structure. These rates are typically uniform across a customer class and across time (both hours of day and days of the year). Moreover, typical retail rates do not change in response to an individual customer’s actions. Consequently, individuals’ prices do not reflect their

4 On April 25, 2001, the Washington Utilities and Transportation Committee approved a trial time-of-use rate for more than 300,000 of Puget Sound Energy’s customers.

incremental impact on system costs, nor do they give customers the proper incentives to consume energy more efficiently. Reforming rate structures at the state level and allowing prices that reflect actual costs at the time of consumption would provide real financial incentives for end users to curb usage during peak periods. Such a structure would also reduce the amount of cross-subsidization across ratepayers within a customer class.

Second, the industry today does not yet have the adequate metering and billing infrastructure in place to implement dynamic pricing. Currently, nearly all mass-market residential and commercial customers have meters that record consumption on a monthly basis. Since neither the distribution utility nor the retail provider can observe the customer's actual consumption patterns during the day, it is impossible to link customer actions to wholesale market prices. Thus, necessity forces utilities to assign customers a statistical load profile that may accurately reflect the *average* consumption of similar homes or businesses, but that does not reflect the customer's *actual* usage. Without such specific usage information, the customer cannot benefit from shifting or curtailing load in response to higher prices.

To obtain the amount and quality of data necessary for efficient consumption decisions, the utility must upgrade its metering and billing infrastructure. At a minimum, any dynamic pricing program requires that data be collected on a more frequent (e.g., hourly) basis. Luckily, a number of recent advances in automated meter reading technology, the expansion of Internet access, and the declining cost of digital communications has made real-time pricing systems more practical for smaller commercial and residential customers. But despite this fact, many utilities are still concerned about the longer-term cost recovery associated with advanced metering investments—a fact that could prohibit widespread deployment. Several proceedings currently underway call into question the role of utilities in meter reading and billing; as a result, management teams are still reluctant to invest in what may become the next major "stranded asset."

One final complication exists in the deployment of effective dynamic pricing programs—a classic free-rider problem. As discussed above, approximately 20 percent of total savings comes from individuals either shifting or curtailing their consumption during peak price periods. The remaining 80 percent is generated by the lower wholesale peak prices that result from reducing overall demand during peaks. As more customers respond to wholesale market conditions, demand for peak energy drops, resulting in a lower market-clearing price for all energy consumed at that time.

In aggregate, relatively small individual reductions in demand can potentially create significant savings. For example, our analysis shows that a 10 percent reduction in peak could result in a 20 to 30 percent reduction in peak price on average.[5] Another report by The Brattle Group found that a 10 percent reduction in demand could lead to a 50 percent reduction in peak price.[6] Moreover, this collective benefit accrues to all customers,

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5 Calculated by determining the average price reduction for a corresponding drop in peak demand.

6 A report by Peter Fox-Penner and Dean Murphy of The Brattle Group. They found that as little as a 10 percent reduction in price spikes (fly-ups) could result in as much as a 73 percent reduction in peak price.

regardless of whether they participate in dynamic pricing or have made investments in improving the utility metering and communications infrastructure.

Since so much of the value comes from collective actions, there is a risk that consumers or their utilities, especially in the mass-market residential or commercial sectors, will not invest in real-time metering of their own accord. However, unless significant customers are offered this opportunity, the economics will not be positive. By our estimates, at least half of mass market customers would need dynamic pricing capabilities in order to justify the infrastructure expense. Such a wide-scale deployment will require an institutional solution.

THE NEED FOR AN INSTITUTIONAL SOLUTION

In spite of the clear and measurable benefits, these obstacles are preventing the deployment of dynamic pricing solutions. We believe an institutional solution is called for to encourage and support the deployment of the systems and technologies which will enable dynamic pricing. Without such a solution, peak energy consumption will continue to be unnecessarily high, prices will be more volatile than necessary, and more energy infrastructure than necessary will be required. A more efficient solution exists, one that combines effective demand-side and supply-side actions.